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Disintegration of the 15-day osmium

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With 4 figures in the text

The 15-day Os^{193} was recently studied by BUNKER et. al. (1) using a β-ray spectrometer with good resolution. Previous to this, absorption and coincidence measurements were also reported. Till now it has not been possible to propose a disintegration scheme for this isotope. The main difficulty encountered in this case is that almost the whole β-continuum is masked by Auger and internal conversion electron peaks. So it was impossible to make Fermi plot of the β-spectrum and decide whether it is simple or not.

Soon after the present work was started BUNKER et. al. (1) published their paper; they could not also make Fermi plot of the β-spectrum or decide whether the β-spectrum is simple or not. In the present investigation spectroscopically pure osmium sponge was irradiated for one week in the Harwell pile. As the relative abundances of the Os^{184}, Os^{190}, and Os^{192} are respectively 0.018, 26.4 and 41.0 and since the half-life of Os^{185} is about 97 days, very little of Os^{185} was formed by this short period of irradiation. Thus one main difficulty, namely the intense Auger electrons arising from the K-capture Os^{185}, was overcome to a large extent.

Using some twelve points in the region between the K and L-lines of the 128 keV γ-ray, it was possible to make Fermi plot and decide about the maximum energy of the β-rays. It has also been possible to decide whether there is an inner β-ray group (100 keV) of appreciable intensity, by performing the βe^- coincidences in the spectrometer.

The spectroscopically pure osmium obtained from Harwell after one week's irradiation in the pile, was allowed to decay for about three weeks in order that the 32 hour Os^{191} may die down and then chemically purified in the radio-chemical laboratory of this institute. The resulting osmium sulphide powder was well grounded and spread over an Aluminum backing of 2 mg/cm^2 with a uniform thickness of about 2 mg/cm^2. The spectrometer (2) was set for about 4.5% resolution. Fig. 1 gives the β-spectrum. It shows four electron peaks at 29.2, 38.3, 51.9 and 114.8 keV. The first two are the L and M lines of the 42 keV γ-ray while the last two are the K and L-lines of the 128 keV γ-ray. The γ-spectrum gave the same values for these two γ-rays. The line at 51.9 keV is at 1.35 amp. current; if it were due to Auger electrons predominantly, then it should have occurred at 1.30 amp. No electron peak at about 835 gauss-cm corresponding to the one observed by BUNKER et. al. (1) was obtained in this spectrum. This shows that the Auger electrons are of relatively

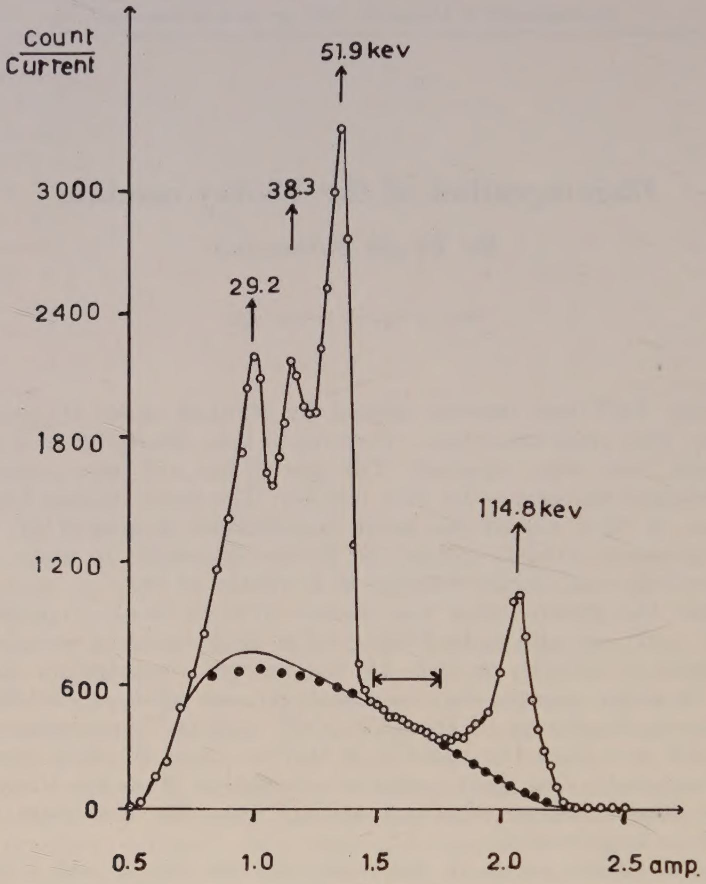

Fig. 1

small intensity. The points in between the K and L-lines shown by a horizontal arrow in Fig. 1 were used in making the Fermi plot shown in Fig. 2. The maximum energy of β-rays was thus found to be 143 ± 2 keV. The inner spectrum in Fig. 1 was drawn from the full points, which were obtained by extrapolation of the Fermi plot on the assumption that it is a straight line.

βγ-coincidences were observed using a standard set up and it was found that the number of βγ-coincidences per β is independent of the thickness of absorber before the β-tube. This confirms that there is no β-component of low intensity leading to the ground level of the 128 keV γ-ray.

The procedure followed in making the βe^- coincidences was similar to the one in the case of Ba^{131} (3). The L line of the 42 keV γ-ray was focussed into the far off β-tube and absorbers of different thicknesses were used between the sample and the nearby β-tube behind the sample. The resolving time of the

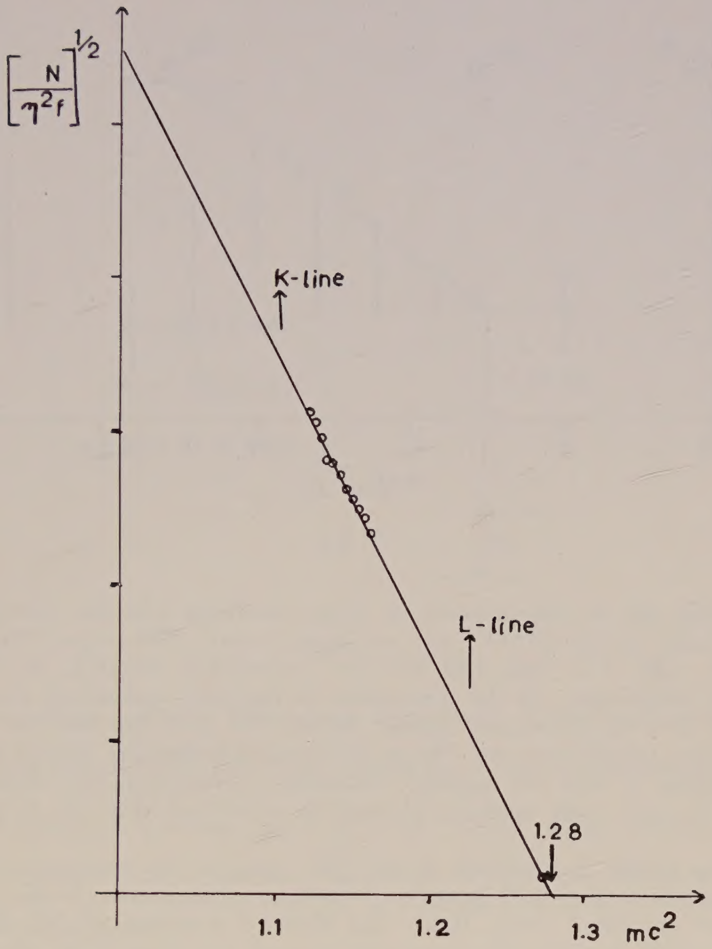

Fig. 2

coincidence circuit was 0.4 micro-second. Fig. 3 gives the βe^- coincidence-rate versus thickness of absorber. It shows that the βe^- coincidence rate is independent of the absorber thickness for the L electrons of the 42 keV γ-ray. If it is assumed that coincidences between the L electrons of the 42 and 128 keV γ-rays are relatively very few compared to the coincidences between the continuous β-spectrum and L electrons of the 42 keV γ-ray, then Fig. 3 suggests that the β-spectrum is simple. In view of the fact that almost the whole of the β-spectrum is covered by conversion lines and it is not possible to decide about the complexity of the β-spectrum from its Fermi plot, this is the only way left to decide whether the β-spectrum is simple or not. A decision on the basis of the comparison of the intensities of 42 and 128 keV γ-rays has not

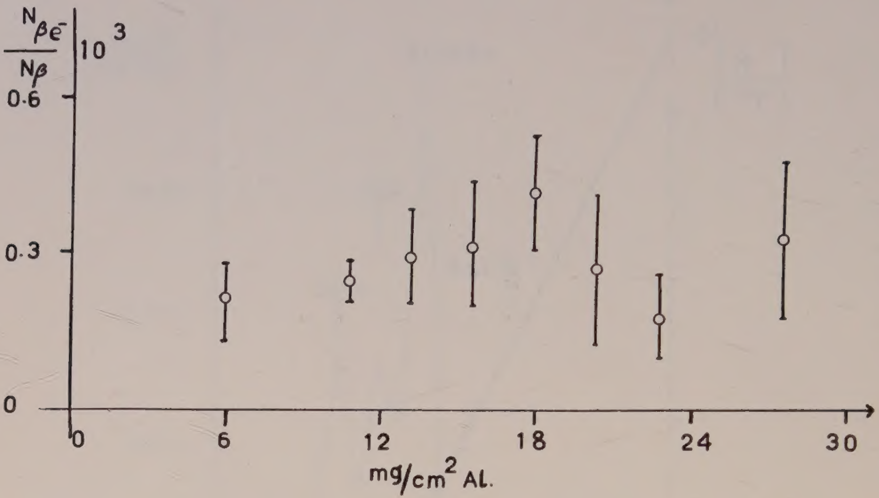

Fig. 3

been possible due to the presence of Auger electrons and the internal conversion coefficient of the 42 keV γ-ray not being known. The ranges of electrons of energy 50, 100, 115, and 145 keV are respectively about 5, 15, 18 and 27 mg/cm^2 of Aluminum. If the β-spectrum is complex containing another component of β with maximum energy about 100 keV (as may be expected), then the βe^- coincidence rate versus thickness of absorber should have come down between 5 and 15 mg/cm^2 thickness of absorber. As there does not seem to be any such tendency it may be concluded that the β-spectrum is simple.

The ratio of the L electrons of 128 keV γ-ray to the continuous β-spectrum was found to be 0.20 $\pm$ 0.02 from the β-spectrum. Comparison of this value with the values calculated from Hebb and Nelson's formulae (4) for electric and magnetic multipoles of different order showed that this value fits best with electric quadrupole radiation. Hebb and Nelson's formulae for K to L ratio (4) and Rose's tabulations (6) of K conversion coefficients show that the $\frac{N_K}{N_L} \sim 2.3$ as well as $\frac{N_K}{N_\beta} \sim 0.5$, found from the β-spectrum are also consistent with electric quadrupole radiation. So most probably the 128 keV γ-ray is electric quadrupole radiation.

The ratio of the rates of βe^- coincidences when the K and L-lines of 128 keV γ-ray were focussed, was found to be 2.1. This may be taken to be a more reliable value for $\frac{N_K}{N_L}$ than the one obtained from intensity measurements from the β-spectrum, as in the former case only those electrons that are coincident with the continuous β-spectrum are effective whereas in the latter case the Auger electrons due to the K-capture Os^{185} isotope will also come into effect. However, even this coincidence method cannot avoid the Auger electrons arising from the internal conversion of the γ-rays of Os^{193} as they

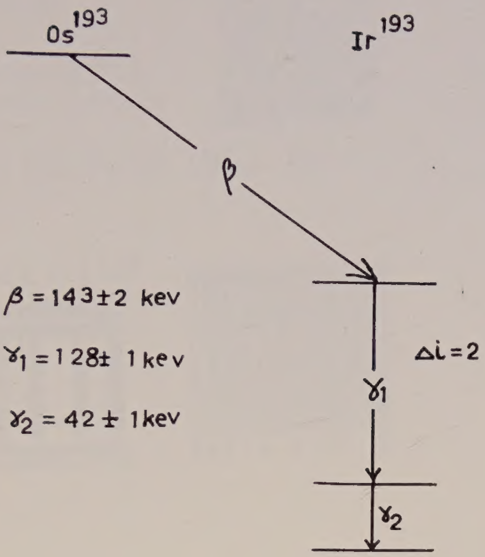

Fig. 4

are also coincident with the continuous β-spectrum. A similar βe⁻ coincidence method in the case of the 42 keV γ-ray yielded $\frac{N_L}{N_M} = 1.8$. Intensity measurements from the β-spectrum, however, gave $\frac{N_L}{N_M} \sim 1.3$. These values should of course be taken as estimates only. The βe⁻ coincidence experiments showed that neither the 42 nor 128 keV γ-rays are emitted by a metastable level of half-life greater than about a micro-second.

Using the value of $\beta_{\max} = 143$ keV and $T_{\frac{1}{2}} = 15$ days, the comparative half-life for this β-transition comes out to be 2.05×10^5 sec., or log (ft) = 5.3. This places this β-transition in the normal allowed group according to Nordheim (5). The probable disintegration scheme is shown in Fig. 4.

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